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Abstract
This paper is concerned with the empirical relationship between biodiversity conservation values and income. We use random effects panel models to examine the effects of income, and then GDP per capita, on willingness to pay for habitat and biodiversity conservation. In a meta-analysis, 145 Willingness To Pay estimates for biodiversity conservation where existence value plays a major role were collected from 46 contingent valuation studies across six continents. Other effects included in the meta-analysis were the study year; habitat type; continent; scope as presented to respondents; whether WTP bids were for preventing a deterioration or gaining an improvement in conservation, whether a specific species or specific habitat was protected; whether the questionnaire used a dichotomous choice or an open-ended format; distribution format; and the choice of payment vehicle. GDP per capita seemed to perform as well as an explanatory variable as respondent's mean stated income, indicating that it is wealth in society as a whole which determines variations in WTP. Our main conclusion is that the demand for biodiversity conservation rises with a nation's wealth, but the income elasticity of demand is less than one.

JEL Codes: Q2, H4, D6

Key-words: meta-analysis, income effects, contingent valuation, existence values, Environmental Kuznets Curve.

1. Introduction

This paper is concerned with the relationship between Willingness to Pay (WTP) for biodiversity conservation and income. By "biodiversity conservation", we mean actions which protect or improve either habitats or species. Two contrasting definitions of income are used: first, average household income (or, in a minority of cases, average personal income) in the sample from which the WTP estimates are drawn: and second, GDP per capita for the country from which the sample is drawn. Some 46 Contingent Valuation studies from 6 continents form the data base for the paper. We focus on studies which have tried to estimate non-use values for biodiversity conservation. Our main research question is this: is there empirical evidence that willingness to pay for biodiversity conservation increases with income? The importance of this question relates to current debates over the existence of an "Environmental Kuznets Curve" for environmental quality in general, and for biodiversity in particular (Deacon and Norman, 2006; McPherson and Nieswiadomy, 2005). It also relates to an older literature dating to Krutilla and Fisher (1975), on how preservation values for natural environments can be expected to evolve over time, considering that depletion of many natural resources is irreversible; and to debates over the distributional effects of environmental policy (Kristrom and Riera, 1996; Ebert, 2003).

2. Determinants of the demand for environmental quality

In 1955 Kuznets suggested an inverted U-shaped relationship between an indicator of income inequality and the level of household income (Kuznets, 1955). A relationship similar to the Kuznets curve has been found between national income (GDP per capita) and a number of pollutants, and this relationship is often referred to as the Environmental Kuznets Curve (EKC) (Grossman and Krueger, 1995). The relationship implies that as economic growth occurs, pollution increases up to a certain income level. After this “turning point”, pollution begins to decrease. Suggested reasons for this empirical regularity are structural economic change, technological development, and – what is key to this paper – an increasing demand for environmental quality and environmental regulation as real per capita incomes increase (Barbier 1997). Empirical evidence both in support of and in contradiction of a U-shape relationship between pollution and income can be found in the literature (Deacon and Norman, 2006). Barbier (1997) argues that most empirical studies show that a very high level of income per capita is needed before environmental quality begins to increase, implying that most countries have not yet reached a turning point, even if it exists for some pollutants. Of direct relevance to this paper is the search for EKC-type relationships for measures of biodiversity. McPherson and Nieswiadomy (2005) investigated the relationship between species counts for threatened mammal and bird species in 113 countries and real per capita income, finding indications of an EKC shape in both cases. In other words, species numbers initially decline as incomes rise, but then start to rise again.

As noted above, an important “driver” in EKC theories is the effect of income growth on the demand for environmental quality (see, for example, Bruvoll et al., 2003). It has long been argued that environmental quality is a luxury good, with an income elasticity of demand greater than one (Kriström and Riera, 1996). If this is so, then demand for environmental goods, manifested either as consumers buying greener products, or demanding tougher environmental legislation, will grow disproportionately quickly as incomes rise. However, both Kriström and Riera (1996) and Hökby and Söderqvist (2003) question this assumption.

An important distinction in this literature is between the income elasticity of demand and the income elasticity of WTP. Most goods valued using the kind of stated preference methods upon which Kriström and Riera base their conclusions are public goods which are in fixed (rationed) quantities from the perspective of the individual, so that the individual cannot continuously vary the quantity of goods he or she demands (an exception is recreational trips to an outdoor recreational resource such as a national park). Stated preference studies offer individuals the chance to bid on a very limited range of supply options for the public good. Therefore the construction of a conventional income elasticity of demand measure is problematic. A more suitable measure of income responsiveness is the income elasticity of WTP, $\varepsilon_{w,}$ which can be defined as:

$$\varepsilon_w = \frac{y}{WTP}\frac{\partial W}{\partial y} = \frac{\partial(\ln W)}{\partial(\ln y)} \qquad [1]$$

where *y* is income and *W* is a "bid function" for WTP (Flores and Carson, 1997; Hökby and Söderqvist, 2003). Therefore we cannot use a distinction between luxury good and normal goods as discussed above. However, it is possible to quantify the distributional pattern of WTP: when $\varepsilon_w<1$ the environmental good is said to be distributed regressively, and distributed progressively if $\varepsilon_w>1$. If $\varepsilon_w<1$, then projects which promote environmental conservation have the possibility of benefiting poorer households more than rich households, in the sense that the proportion of WTP to income is decreasing as incomes rise – an environmental good for which $\varepsilon_w<1$ has proportionately higher benefits to poor groups than to rich groups (see Ebert, 2003).

It is also useful to distinguish between the kinds of environmental goods for which people are asked to state a WTP amount. Use values dominate total economic value for many environmental goods, such as clean water, better air quality and reduced risks to health, and many meta-analyses of stated and revealed preference values are focussed on such goods. In this paper however we will focus on non-use values for biodiversity and habitats. Non-use values for biodiversity and habitats might be argued to be more progressively distributed than use values. The income elasticity of WTP for goods the benefits of which are dominated by non-use values may well be different than the income elasticity of WTP for environmental goods for which a change in supply has more immediate or more obvious personal consequences than losses in biodiversity. The main aim with the present study is thus to investigate the income elasticity of WTP for an environmental good – biodiversity conservation – where non-use values are believed (by those conducting the primary studies on which our meta-analysis is based) to play a major role.

Environmental Kuznets Curve studies focus on average incomes across a whole society as determinants of environmental quality, by using explanatory variables such as real GDP per capita. In contrast, stated preference studies use measures of personal or household income as a determinant of WTP. Sometimes a statistically significant effect is found between individual or household income and WTP (e.g. Bergstrom et al.1985; Brouwer and Bateman, 2001; Macmillan et al.2001; Veisten et al. 2004), whilst sometimes no significant effect is found (Macmillan et al.2001; White et al.1997). Accordingly, in this study we investigate both the effects of wealth in society, measured by GDP per capita, and household (or personal) income on WTP for biodiversity and habitat conservation. As we note later, self-reported income in Contingent Valuation studies is in any case a problematic choice of explanatory variable when studying the causes of variations in WTP.

Clearly, many factors other than income or wealth can affect WTP. Most obviously, studies find different WTP amounts because they value different goods. For studies looking at wildlife and habitat conservation, the specific habitat or species being considered, whether it is unique, and whether it is known to the public is important (Christie et al, 2006). Moreover, whether a charismatic or a rare species is to be preserved can matter (Metrick and Weitzman, 1994, Hanley et al. 2003), along with the size of prospective change in the habitat or species. Other reasons for variation in WTP are found in the valuation methods being applied. Focusing on differences in stated preference methods, differences are found between Contingent Valuation (CV) and choice experiments (Riera et al. 2007, Boxall et al. 1996, Hanley et al. 1998a, Hanley et al. 1998b, Lehtonen et al. 2003) and between the different formats in CV – for example, between dichotomous choice, open ended or payment card designs (Johnson et al. 1990; Reaves et al., 1999; Welsh and Poe, 1998). Finally, differences in WTP might be caused by non-income differences in the population of beneficiaries being studied (e.g. Boiesen et al., 2005; León, 1996; Turpie, 2003; Lindhjem, 2007), for example in terms of rural versus urban location.

3. Meta-studies in environmental valuation

Meta-analysis started as a tool in medical research for analysing knowledge accumulated from many different studies (Hunter and Schmidt, 2004). Later, its use extended to other areas like economics (Pang et al. 1999) and more specifically environmental economics (van den Berg, 1997, Bal et al. 2002). One aim of meta-analysis can be to analyse consistency across studies, controlling for factors (such as income) which may be thought *a priori* to drive variations in outcomes (such as WTP estimates). One of the first applications within environmental economics was Smith and Kaoru's (1990) analysis of travel cost estimates of recreation values. Other applications are analyses of values for rare and endangered species (Loomis and White, 1996), for coral reefs (Brander et al., 2007), for groundwater protection (Poe et al., 2000), for wetlands (Brander et al., 2006, Brouwer et al. 1999, Woodward & Wui, 2001), for forests (Lindhjem, 2007) and forest recreation (Bateman and Jones, 2003). Smith and Osborne (1996) use the method for a more methodological purpose, namely as a test for scope effects. Income effects on willingness to pay are analysed in some of the above-mentioned studies. Brander et al (2006) find GDP per capita to be positively and significantly correlated with WTP and Poe et al. (2007) find a positive and significant income effect. Schläpfer (2006) takes a slightly different approach, and investigates what determines whether income is statistically significant within a study. He does that using a logit model to test for the presence of a significant income effect. In 36% of the studied cases, income is significant. Interestingly for this paper, whether a study was classified by the author as eliciting non-use (passive use) values compared with use values did not have a significant influence on the presence of an income effect.

An important step in a meta-study is the development of a protocol for including or excluding studies: for example, restrictions can be imposed for reasons of geography, valuation method applied, topic, or quality of the study. Meta-analyses in environmental economics are normally restricted both geographically and with respect to topic, partly due to a desire to make use of results for benefit transfer. Exceptions are studies with a focus on methodological differences. In our study we do not restrict the studies to be included on geographical grounds: on the contrary, we want to include as wide a spatial spectrum as possible in order to analyse income effects across countries. Restricting the analysis to specific habitats also makes little sense, since habitat variation is so great at the global level, and therefore we include studies for any habitat. Instead we restrict the studies to those which focus on estimating non-use values for biodiversity and habitat conservation, since our purpose is to test for a relationship between willingness to pay and income which would be consistent with the existence of an EKC for biodiversity conservation. Only a few previous meta-studies have focused on such non-use values (e.g. Lindhjem, 2007). Furthermore, other studies focusing on the existence of an EKC for biodiversity analyse the causality going from income to biodiversity *per se* (e.g. McPherson and Nieswiadomy, 2005), whereas we look at the effects of rising income on WTP for biodiversity.

4. Collection of data

This meta-analysis is based on 46 contingent valuation studies (see Appendix 1) which report 145 relevant WTP estimates. Information is taken from published papers, papers in the process of publishing or reports which are at a publishable level. Most of the papers can be found on Web of Science. Criteria for selection of studies were focus on existence value and access to income measures. All the studies value nature goods where the researchers claim that existence value plays a major role. As existence and use value are seldom separable, we do not attempt to exclude estimates of use value. However, studies which *focus* on use values alone or studies carried out solely on respondents visiting an area are excluded. Information regarding respondent's income was also a requirement for inclusion, and lack of income data was the main reason for exclusion of many studies. Where sufficient information could not be found in the paper, the lead author was contacted (some studies have been excluded as the authors could not be contacted). Where income data was missing and the paper states that the sample was representative for the population, national statistics have been used instead. This is the case for 8 studies (15 estimates), one from Australia and 7 from the USA. Otherwise, sample income information has been collected from authors. A measure of gross domestic product per capita (GDP) is included for each country in the year for which the original study was undertaken. Data on GDP was obtained from IMF (2007a). Most studies value several supply levels of the same good or use different estimation procedures to come up with a range of value estimates. We have decided to use all the WTP estimates available in order not to hide eventual estimation differences by averaging them. Multiple estimates from a single study are treated as a panel. The studies included were carried out all over the world, although with a focus on developed countries. It has been difficult to find valuation studies from poor countries which focus on existence values, although there are a few. Table 1 shows an overview of the estimates.

[Insert Table 1 about here]

Some of the variation in the willingness to pay data may be caused by differences in the way the good was presented to respondents. In order to analyse, this we included two characterisation variables. One variable indicates whether the project in question preserves habitat or species, i.e. "saves" objects which would otherwise disappear, or whether the scenario involved an improvement in preservation conditions. The other variable tries to capture the scope of the conservation issue as presented to respondents. It takes the value zero (a "part value") if it was explained to respondents that a given project is a part of the protection scheme for nature in a country; and the level of one (a "whole value") if the protection is taken to cover all of a policy (the establishment of a national park not considering substitutes, the protection of a species across a whole country, etc.). Notice that what is considered part or whole is determined by what was presented to respondents, not what is a correct biological distinction. Sometimes external scope tests are carried out in a study, but if the substitutes or relative importance of the good is not mentioned to the respondents, the variable scope takes the same value. The reason for doing this is that the magnitude of goods which consist largely of existence value will often be difficult for people to have a good grasp of. Thus the valuation context constructed for them is often seen as very important for their understanding thereof (see e.g. Bateman & Mawby 2004, Mitchell & Carson, 1989). All monetary terms are converted to 2006 US $, by first inflating by the national consumer price index and then using purchasing-power-parity (PPP) to convert to values to US $. Inflation and PPP estimates are from the International Monetary Fund (IMF 2007a).

[Insert Table 2 about here]

Table 2 summarises the variables used in the model. Educational achievement would have been an obvious variable to include, but as it is not reported on a common scale this was not possible. The variable *study year* may capture unobserved development in the contingent valuation method as well as in the societies studied. In some of the analyses fewer than 145 estimates are used due to missing information. Income is reported as household income in 124 cases and personal income in 17 cases , with 3 cases being unspecified. WTP is reported in per household terms in 110 cases, per person terms in 33 cases, and one case is unspecified. Personal income and personal WTP statements are not converted to the corresponding household measures as household size is generally not reported for the studies related to individual payment. Where personal income measure is used, the corresponding payment is always personal and will therefore not result in interpretation problems assuming respondents have interpreted the right context, and there is no income pooling (cf. Munro 2005). For some studies personal payment and only household income is reported. These studies are excluded in the analyses where income is modelled, whereas all studies reporting personal payment are excluded in models based on GDP.

5. Analysis and results

Figure 1 shows WTP for biodiversity conservation as a function of income depending on whether income was measured per person or per household. One outlier is observed (a mean WTP of over $700). According to the original study (León, 1996) this estimate's reliability is questionable and consequently it was excluded from the analyses below. Another potential outlier is seen with a WTP of $316. This observation is from a study regarding preservation of both a number of species and a specific species (Jakobsson and Dragun, 2001), and the difference in the estimates in the original study seems to be caused by the specification of the good. Therefore this potential outlier is not removed.

[Insert figure 1 about here]

The analytical starting point was an ordinary least squares linear regression with use of the Huber-White technique to correct for heteroscedasticity and serial correlation (see the procedure described in Greene, 2002). As most of the reported studies report more than one estimate, this ultiple reporting could be used as a stratification process. Thus we used the process described by Rosenberger and Loomis (2000) to test for panel structures in the data, in that we specify:

$$WTP_{ij} = \alpha + \sum_{i=1}^{n} \beta_i x_{ij} + \mu_{ij} + \varepsilon_i \qquad [2]$$

where WTP_{ij} is WTP for the *i*'th observation in the *j*'th strata (here study), α is a constant, x_{ij} is a vector of explanatory variables, with a panel effect μ_{ij} and an error ε_i ~$N(0, \sigma_\varepsilon^2)$. A Breusch and Pagan's Lagrange multiplier test was performed to test whether $\mu_{ij} = 0$. For a random effects model with income as the only explanatory variable, this test showed that a model with equal effects was rejected, and that a panel estimation was therefore appropriate ($\chi^2 = 42.42$, p=0.000 with N=128 and j=42). The Breusch and Pagan Lagrange multiplier test and subsequently performed on all the models presented below and gave the same conclusions, namely that a random effects panel model was the best fit to the data, compared to a simple pooled model. A random effect models was chosen instead of a fixed effects model due to no a priori expectations of the fixed study effect being correlated with other study characteristics. Furthermore, for the GDP version of the models a fixed effects specification is not possible, since GDP is not separable from the fixed study effect.

[Insert Table 3 about here]

Looking at Figure 1, no obvious functional form is apparent for the relationship between income and WTP. Several functional forms were tried in the random effects panel models – a linear, a semi-log, a quadratic and a double log version. Using Wald tests, the best specification was obtained by the log models (χ^2=7.73 with p > χ^2=0.0054 for the semi-log model and p > χ^2=0.0076 for the double-log model vs. p > χ^2=0.16 for the linear and p > χ^2=0.60 for the quadratic). A similar plot of WTP against GDP per capita does also not show an immediate apparent relationship, and again log models performed best. Income and GDP per capita are highly correlated (0.68), and therefore they were specified as explanatory variables in separate models (that is, income and GDP per capita could not be included in the same model, nor was it desirable to do so, since we are interested in comparing the responsiveness of WTP to these different measures of resources).

Four simple random effect models of the relationship between income or GDP alone with WTP are reported below. The specifications are:

Model 1: Random effects model of WTP, β_1 is the parameter for ln(income per year)

Model 2: Random effects model of ln(WTP), β_1 is the parameter for ln(income per year)

Model 3: Random effects model of WTP, β_1 is the parameter for ln(GDP) per capita per year

Model 4: Random effects model of ln(WTP), β_1 is the parameter for ln(GDP per capita per year)

Results are shown in Table 3. It can be seen that both income and GDP per capita are significantly and positively related to willingness to pay for biodiversity conservation. The single-log models perform slightly better for both income and GDP if evaluated based on the R^2 measures. However, since the studies from which the database is constructed vary in many respects other than in the income and WTP values reported, models were then estimated with all the meta-analytic variables shown in Table 2 included. Results are shown in Table 4, this time focussing on just the semi-log versions, which fitted best. In Table 4a, all variables described in Table 2 are used in the estimation.

[Insert Table 4 about here]

From Table 4a it can be seen that neither income nor GDP per capita is significant in these fuller specifications. Interestingly, not many of the study design variables are able to explain the variation in WTP. The only significant variables are whether the payment scenario concerned a specific habitat, and whether dichotomous choice or open ended format was used. The correlation between income and the other variables is also shown in the table. Apart from the obvious fact that continent and GDP per capita correlates somewhat, it is seen that the highest correlations are found between format and both GDP per capita and income, between study year and income and between donation and GDP. Generally the correlations are not very high. When a non-panel model was estimated, correlations were much higher – often between |0.8| and |1| [1].

Since Table 4a shows that most of the study design variables were insignificant determinants of WTP for biodiversity conservation, we re-estimated the model for income and for per capita GDP including only those study design variables which were significant at 95% from Table 4a, that is, *specific habitat* and *method.* Results are shown in Table 4b. These show that the parameters on income and on GDP are now significant at the 90% level, although still not significant at the 95% level. Based on a Hausman test, we could not reject the null hypothesis of equivalence between the parameters on income and GDP from the income/GDP only models shown in Table 3, and those from the reduced form models shown in Table 4b. We can also see that the size of the parameters

[1] We also tried to estimate a model where WTP was averaged for studies originating from the same study as e.g. also Lindhjem (2007) does. Though R^2 increases to 0.26 and 0.31 for the models based on income and GDP per capita respectively, a panel structure could still not be rejected (results not shown). Furthermore, these models have a very high correlation between the variables included.

on income and per capita GDP comparing Tables 3 and 4b is very similar (eg 29.12 in Table 3 for per capita GDP, and 29.11 in Table 4b). The main conclusion is thus that income and GDP are significantly related to willingness to pay for biodiversity conservation: rising income leads to rising WTP.

Finally, it is interesting to investigate what is driving the internal significance or otherwise of the income variable in the studies which form our dataset[2]. 56 of the 145 data points reported internal significance of income as an explanatory factor for WTP, whilst 39 reported insignificant effects. Some 50 data points did not specify which of these was the case; however, often income is only reported if it shows significance in terms of impacts on WTP, so some of these observations may represent studies where income did not have a significant effect on WTP. Following Schlapfer (2006), we estimated a logit model of whether the internal income significance could be determined by any of the study design variables shown in Table 2. Results are shown in Table 5. Interestingly, both increasing income and increasing GDP levels caused lower likelihood of internal income significance. Whether a survey was concerned with protecting existing biodiversity or increasing biodiversity conservation *(save)* was also significant, as was use of a voluntary payment mechanism (*donation*) and whether a dichotomous choice or open-ended format was used (*method*). Focus on a specific species or habitat also had a significant effect, but only in the GDP version of the model.

[Insert Table 5 about here]

6. Discussion

The analysis presented above focuses on whether there is an income effect on WTP for biodiversity conservation where non-use values play a major role. Studies of WTP usually analyse the

[2] We thank one of the referees for this suggestion.

relationship between income and WTP within a survey sample. In fact, only 39% of the studies used to form the database show that such a correlation was positive and significant. In this study the focus is on external tests of dependence across studies, contexts and societies, and we were able to find a positive relationship between income or GDP per capita and WTP for biodiversity conservation, although the detected strength of this relationship is not as great as might have been expected, nor is it estimated with high precision. This may be due to the high level of noise in the data, causing the significance and strength of inter-linkages to be dependent on the specific model used. We also find that GDP per capita is as good a predictor of WTP for biodiversity conservation as income. Income and GDP per capita are of course highly correlated (+0.7 in our data). However, one can argue that irrespective of the empirical results, GDP per capita is a preferable variable to relate to WTP if one is interested in the effects of growing wealth on the demand for biodiversity conservation, which as we noted above, is one of the main theoretical drivers underlying the Environmental Kuznets Curve. This is for two reasons. First, household (personal) income figures from CV surveys are self-reported, and thus may be inaccurate in the sense of deliberate mis-statement. Income reports are also typically only provided by respondents as a range (and thus are imprecise), but more importantly are poorly defined: do all CV respondents take the same view in calculating all their income sources before responding? Do all respondents take the same view about reporting pre- or post- tax incomes? Non-wage income and income for some household members may be under-reported or not reported al at all. In other words, income as a variable in a meta-analysis of CV studies is poorly defined. GDP per capita, in contrast, is well-defined and consistent across countries, yet still represents the essence of what income measures try to capture in CV models. Second, if we are trying to understand how the demand for environmental quality increases as countries get richer – a key underlying story in the EKC literature – then GDP per capita gives a wider picture of "available resources" or spending power for society than does household income, since it represents all sources of income within an economy. In relating findings to the EKC literature, the main finding is thus that within this data, rising GDP per capita increases WTP for biodiversity conservation, although the effects are not always strong.

Based on the results from the double-log models in Table 3 we find an income elasticity of WTP for biodiversity conservation to be +0.38, both when using GDP per capita and household/personal income, indicating that WTP for biodiversity conservation is regressively distributed. As incomes rise, this means that the fraction of income that will be offered as a maximum payment for biodiversity conservation will fall (ie that $\partial\left(WTP/y\right)/\partial y < 0$). This is noteworthy, especially since the focus here is on existence values and not on use values, and indeed this is also how the respondents seems to have understood the CV questions asked in the studies from which our data is constructed. Thus the focus on non-use values does not seem to change the conclusions from Kriström & Riera (1996) and Hökby & Söderqvist (2003), that WTP income elasticities lie between 0 and 1. Still the conclusion remains that the richer a country, a given rate of economic growth will translate into a larger absolute WTP for conservation than in a poorer country.

A critique of this study could be that it tries to cover goods that are too different to each other (for example, elephants in Sri Lanka versus wetlands in Norfolk, England). It is therefore very interesting that neither the *continent* nor the habitat-type variables (*habitats: sea, habitat: wetlands*, or *habitat: open areas*) seem to cause systematic changes in WTP according to the results shown in Table 4a. This might indicate that nature protection *per se* is what is valued in the individual CV studies, rather than the specific habitat in question. This could be due to a high level of warm glow or moral satisfaction being present in the WTP responses as indicated by the variable *scope* not being significant. However, the scope variable is difficult to construct across studies, and therefore is a weak criteria as used here. The small difference between habitats could also be an indication of respondents having a high willingness to trade-off different nature goods within the broad habitat categories used here. This last interpretation is supported by one study partly included in the database which compared WTP across several habitats (Jacobsen et al., 2006 & Jacobsen & Thorsen, 2008) and found that respondents were very willing to substitute (trade-off) between them. An alternative view is that the way in which habitats have been characterised in this meta-analysis is too crude. For example, a boreal and a tropical forest are very dissimilar goods, though we group them together here.

Another grouping of the goods valued used was whether a study focused on specific species or habitat protection. Surprisingly the protection of species is not a significant determinant of WTP, whereas protection of habitats is (and it is positive). We could also have expected that the moral issues of saving species and habitats in decline could cause the variable *save* to be significant, but this is not the case. In the analysis on internal income effects (Table 5) *save* does cause income effects to be less significant, probably indicating a moral issue with paying. Finally we find that dichotomous choice questions tend to give higher WTP values than open-ended formats. This has been noted by other authors such as Bateman et al. (1995) and Johnson et al. (1990). Again it is questionable if a more detailed classification of estimation procedures and re-grouping of discrete choice formats, into e.g. double-bounded and single-bounded, would lead to a different conclusion.

We also looked at the internal income effect in the analyses studies, and based on a logit model of internal income significance, found that increasing income levels causes decreasing significance of internal income effect on WTP (Table 5). Income level and inequality, e.g. measured by the Gini coefficient, is normally not found to correlate closely (e.g. IMF 2007b), so the explanation should probably more be found in the regressive elasticity between studies – that WTP constitutes a smaller proportion of income in rich countries/respondent groups and consequently differences means relatively less to rich respondents.

In the reported models we used a panel-structure for estimates derived from the same studies, in order to allow for differences caused by unobserved factors within studies which are not explained by the explanatory variables used to distinguish variation across studies (that is, which allows for error correlation within studies). This turned out to provide results which were quite different from models based on pooling all estimates and ignoring the panel structure of the data. An averaging procedure for estimates with the same characteristics provided somewhat similar results, but still a panel structure could not be rejected. Consequently, we believe potential strata have to be considered and tested before performing meta-studies. Bateman and Jones (2003) have suggested an alternative approach to dealing with the hierarchical nature of meta analysis data, which they refer to as multi-level modelling. We acknowledge that this appears to be a useful alternative to panel data approaches in future work.

7. Concluding remarks

This paper describes a meta-analysis which considers the variation in WTP for a wide variety of environmental goods brought together under the descriptor of "biodiversity conservation". All other things being equal, this widely-spread net results in a large inherent variation in WTP, which is likely to be mainly due to unobserved factors such as institutional setting, environmental attitudes and biodiversity context. Many of our parameter estimates in the "full model" are insignificant and the R^2 of all our models is relatively low. However, the study makes a contribution exactly because of this broad inclusion. We are able to show that, across countries and habitats, there seems to be a significant effect of wealth on WTP for species and habitat conservation, and that this effect is as well-measured using GDP per capita as self-reported income. As we explain above, there are consistency problems with using self-reported income from CV studies to explain the income elasticity of WTP, yet this is the main way in which previous studies have sought to do this (e.g Poe et al, 2001; Brander et al. (2006) being an exeption by using GDP).

Our main result is that rising income increases peoples' WTP for nature conservation. This might be important for nature conservation plans with long time horizons, as it indicates that as societies become richer, they tend to value biodiversity more highly. Benefits in present value terms can thus be expected to rise over time, independently of any scarcity-induced increase in values. This is a point first made conceptually by Krutilla and Fisher (1975), but now it appears that there is good empirical evidence to back up this claim. However, the income elasticity of WTP for biodiversity conservation is less than unity: environmental protection, on this evidence, is not progressively distributed, despite willingness to pay rising with economic well-being.

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Appendix 1. Studies included in the meta-analysis.

Reference	Year of study	Population	What is valued	Habitat preservation	Species preservation	# of used estimates
Amigues et al., 2002	2000	Toulouse metropolitan area, south-central France	Wetlands /Riparian forests along rivers	yes	no	6
Amirnejad et al., 2006	2004	Iran	Preservation of forest	yes	no	1
Bandara & Tisdell, 2004	2001	Colombo, Sri Lanka	Asian Elephant	no	yes	3
Bateman & Langford, 1997	1991	Great Britain	Conserving broads in present state, freshwater wetland	yes	no	1
Bennett, 1984	1979	Canberry, Australia	Nadgee Nature Reserve	yes	yes	1
Bergstrom et al., 1985	1981-82	Greenville County, South Carolina, USA	Agricultural land	yes	no	1
Boiesen et al., 2005	2004	Denmark	Heathland preservation	yes	yes	4
Bowker & Stoll, 1988	1983	Texas to Alaska, USA	Whopping crane	no	yes	12
Cameron & Quiggin 1994 revised 1998 & Carson et al., 1994	1990/1991	Kakadu region, Northern Territory, Australia	National park (as opposed to mining)	yes	no	2
Chang & Ying, 2005	2001	Taiwan	Programme to sustain agricultural areas, (incl. water and habitat preservation)	yes	no	2
Franco et al, 2001	1999	Venice Municipality, Italy	Establishment of agroforestry networks	yes	no	1
Garcia-Lopez, 2006	2005	Puerto Rico	Manatee protection	no	yes	2
Ghani, 2006	2005	Malaysia	Conservation of flora and fauna in forest reserve	yes	no	1
Giraud et al., 1999	1995	Southern Utah, Southeastern Colorado, Western New Mexico, Arizona and the whole USA in a separate sample	Mexican spotted owl	no	yes	2
Giraud et al., 2002	2000	Alaskan Borough, USA	Expansion of Federal Steller Sea Lion recovery program	no	yes	3
Gong, 2003	2001	China	Programme for biodiversity conservation in Nature Reserve	no	yes	2
Hadker et al., 1997	1995	Bombay, India	National park	yes	no	1
Hailu et al., 2000	1995	Alberta, Canada	Conservation programme old growth forest	yes	yes	3
Hammitt et al., 2001	1993	Taiwan	Preservation of wetland	yes	no	2
Heberlein et al., 2005	1998	Vilas ad Oneida Counties, Northern Wisconsin, USA	Water quality, all lakes in county	yes/no	yes/no	3
Holmes et al., 2004	2000	Macon County,North Carolina, USA	Restoration of riparian area	yes	yes/no	8
Jacobsen et al., 2006	2005	A number of counties, Denmark	National park	yes	no	7
Jakobsson & Dragun, 2001 and 1996	1988	State of Victoria, Australia	Conservation of endangered species	no	yes	3
Kwak et al., 2003	2001	Seoul Metropolitan area, Korea	Urban forest, amenity values	yes	yes	1
Lehtonen et al., 2003	2002	Finland	Forest conservation programme	yes	no	1
León, 1996	1993	Gran Canaria, Spain	Group of national parks	yes	no	4
Lockwood & Carberry, 1998	1997	New South Wales, Australia	Preservation of reminant native vegetation	yes	no	2
Loomis & Gonzales-Caban, 1998	1995	California and New England, USA	Protection of old growth forest as habitat for spotted owl	yes	yes	1
Loomis et al., 1993	1992	South-East Australia	Preservation of old growth forest	yes	no	3

Loomis et al., 2000	1998	Adams, Boulder, Weld, Morgan counties in Colorado, USA	River restauration. Protection of riverside habitat and river	yes	no	1
Loomis, 1987	1985	California, USA	Protection of a remote hypersaline lake, preserve ecology, scenic resources and bird population.	yes	yes	1
Macmillan et al., 2001	1995	Scotland, UK	Restoration of a large native forests	yes	yes/no	6
Pate & Loomis, 1997	1990	San Joaquin Valley, California outside San Joaquin Valley, Washington state, Oregon, Nevada, USA	Wetland improvement	yes	no	5
Richer, 1995	1993	California, USA	Desert protection, establishment of 3 national parks and 76 new wilderness areas	yes	no	2
Riera et al., 2008	1999	Catalonia, Spain	Increase forest cover, etc.	yes	no	2
Shechter et al., 1998	1993	Israel	Protection against forest fire - native forest	yes	no	2
Solomon et al., 2004	2001	Citrus county, Florida, USA	Manatee protection	no	yes	1
Spaninks & Hoevenagel, 1995	1993	City of Sneek, Friesland, The Netherlands	Peat medow area	yes	yes	1
Streever et al., 1998	1996	New south wales	preservation of wetlands	yes	no	1
Subade, 2005	2001 - 2002	Quezon City, Philippines	Reefs in national marine park, Philippines	yes	no	6
Tsuge & Washida, 2003	1998	Coastal residents (Osaka, Hyogo, Wakayama, Okayama, Hiroshima, Yamaguchi, Tokushima, Kagawa, Ehime, Fokuoka, Oita), Japan	Restoration of a beatiful shore	yes	yes/no	6
Turpie, 2003	2001	Western Cape, South Africa	Biodiversity, especially fynbos	yes	yes	5
Veisten et al., 2004	1992	Norway	Endangered forestry species	yes/no	yes/no	16
Walsh et al., 1984	1980	Colorado state, USA	Preservation of wilderness	yes	no	1
White et al., 1997	1996	North Yorkshire, UK	Preservation plan for otter, water vole	no	yes	3
White et al., 2001	1997	North Yorkshire, UK	Preservation plan for brown hare, red squirrel	no	yes	2
Zhongmin et al., 2003	2001	China	Restoring ecosystem services (habitat, protection against soil erosion, etc.	yes	no	1

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Figure legend

Figure 1. WTP as a function of gross income (household or personal). Black dots are income measure per household and squares are income measures per person. A linear regression line is shown for interest.

Table 1. Some statistics on the origin of 46 valuation studies, reporting 145 WTP estimates.

Time span: 1979-2005

Study origin	
Africa	5
Asia	26
Australia	14
Europe	54
North America	44
South America	2
Focus of study[1]	
Habitat preservation	95
Species preservation	75
Payment unit	
Per household	110
Per person	34
Unspecified	1
Income unit	
Per household	125
Per person	17
Unspecified	3
Payment interval	
One-time[2]	21
Per year	117

Monthly [3]	6
Unspecified	1
Payment vehicle	
Tax	68
Donation	38
Use charges[4]	17
Free choice[5]	14
Mix[6]	5
Unspecified	3
Questionnaire Format	
Dichotomous choice	92
Open ended	53
Data collection	
Postal questionnaire	67
Face-to-face	47
Telephone interview	15
Electronic questionnaire	14
Unspecified	2
Time of survey	
1979-1989	19
1990-1999	72
2000-2005	54

[1] Sometimes overlapping

[2] One-time payments are not converted to annual payments as it requires extra assumptions on interest rate and duration and would thus result in variation caused by the treatment of data, not the data itself. Instead we have included a dummy variable for the payment interval in the analysis.

[3] Multiplied by 12 to obtain annual payments in the estimations

[4] E.g. water bills

[5] E.g. What was considered right by the respondent

[6] E.g. half tax, half donation

Table 2. List of variables used as explanatory variables

GDP per capita per year
Income per household (or person) per year
Study year
Payment interval. Dummy for one-time payment (vs. annual or monthly converted to annual)
Format. Dummy for written questionnaire (vs. interview)
Donation. Dummy for donation payment vehicle(vs. referendum of mandatory contribution)
Method Dummy for dichotomous choice (vs. open ended)
Habitat. Dummy for : Forest (reference) Open areas Wetlands Sea
Continent. Dummy variables for North America (reference) South America Africa Europe Asia Australia
Specific habitat. Dummy for having focus on preservation of a specific habitat
Specific species. Dummy for having focus on preservation of specific species
Save. Dummy variable for whether the WTP was regarding the securing (preventing a decline in) the existence of a species or habitat, compared to an increase in quantity/quality.
Scope. Dummy for whether respondents were informed as to the limited scope of the project.

Table 3: Estimation results for models based on income or GDP per capita alone.

Semi-log (income)	Coefficient	Stand.Err.	z	P>|z|
log(income)	21.96	7.90	2.78	0.005
Constant	-145.39	75.16	-1.93	0.053
Wald X2	7.73		R^2 (within)	0.0191
P>χ2	0.0054		R^2 (between)	0.0427
N	128		R^2 (overall)	0.0195
Doublelog (income)	**Coefficient**	**Stand.Err.**	**z**	**P>|z|**
log(income)	0.38	0.14	2.67	0.01
Constant	-0.08	1.43	-0.05	0.96
Wald χ2	7.13		R^2 (within)	0.0548
P>x2	0.0076		R^2 (between)	0.0336
N	127		R^2 (overall)	0.0199
Semi-log (GDP)	**Coefficient**	**Stand.Err.**	**z**	**P>|z|**
log(GDP)	29.12	12.82	2.27	0.02
Constant	-208.16	120.38	-1.73	0.08
Waldχ2	5.16		R^2 (within)	0.0000
P>x2	0.0232		R^2 (between)	0.0639
N	111		R^2 (overall)	0.0225
Doublelog (GDP)	**Coefficient**	**Stand.Err.**	**z**	**P>|z|**
log(GDP)	0.38	0.22	1.68	0.09
Constant	0.09	2.21	0.04	0.97
Wald χ2	2.84		R^2 (within)	0.0000
P>x2	0.0922		R^2 (between)	0.0519
N	110		R^2 (overall)	0.009

* significant at the 95%-level, ** at the 99%-level, *** at the pp.9%-level and NS not significant

Table 4a. Estimation results for random effects panel models for income or GDP per capita with all study design variables included. Dependent variable is WTP.

	Income model				GDP per capita model				Correlation with:	
	Coefficient	Stand. Err.	z	P>|z|	Coefficient	Stand. Err.	z	P>|z|	income	GDP
log(income or GDP)	15.61	14.93	1.05	0.296	34.41	31.05	1.11	0.268	1	1
Studyyear	0.87	2.98	0.29	0.771	0.48	3.66	0.13	0.896	0.2787	0.0156
specific species	-12.29	24.33	-0.51	0.613	-12.60	24.13	-0.52	0.602	-0.1707	-0.107
specific habitat	87.24	44.72	1.95	0.051	83.14	48.25	1.72	0.085	-0.1855	-0.2945
save	1.76	39.45	0.04	0.964	-2.89	38.60	-0.07	0.94	0.1827	-0.1311
scope	10.55	12.26	0.86	0.39	8.52	12.68	0.67	0.501	-0.1637	-0.0462
donation	31.40	44.12	0.71	0.477	58.87	50.37	1.17	0.243	-0.1315	-0.2825
method	51.18	18.56	2.76	0.006	58.80	20.32	2.89	0.004	0.0065	0.1272
payment interval	0.21	20.91	0.01	0.992	-14.58	21.31	-0.68	0.494	0.1632	-0.2743
format	0.21	41.85	0	0.996	-16.88	45.78	-0.37	0.712	-0.2102	-0.3128
South America	-47.23	87.22	-0.54	0.588	-111.51	89.67	-1.24	0.214	0.0376	-0.3677
Europe	-14.17	66.09	-0.21	0.83	-3.73	62.74	-0.06	0.953	-0.0828	-0.2709
Asia	-54.85	62.86	-0.87	0.383	-48.51	64.48	-0.75	0.452	0.1171	0.4151
Africa	-46.50	94.56	-0.49	0.623	-58.83	102.78	-0.57	0.567	0.3207	0.2303
Australia	-59.97	49.74	-1.21	0.228	-61.01	48.63	-1.25	0.21	-0.0056	0.0229
Habitat: Sea	-21.28	29.75	-0.72	0.474	-24.28	30.56	-0.79	0.427	0.0419	0.0876
Habitat: Wetlands	-25.19	25.30	-1	0.319	-27.77	26.67	-1.04	0.298	-0.2061	-0.0223
Habitat: Open	-23.04	16.38	-1.41	0.16	-24.78	16.42	-1.51	0.131	-0.1461	0.061
Constant	-1879.40	5987.42	-0.31	0.754	-1281.95	7313.72	-0.18	0.861	-0.3004	-0.0543
N	124				109					
Wald χ2 / P>χ2	55.97	/0.000			49.03	/0.000				
R^2 (within)	0.185				0.171					
R^2 (between)	0.161				0.221					
R^2 (overall)	0.098				0.123					
σμ	97.18				97.80					
σε	41.98				45.09					
ρ	0.84				0.82					

Table 4b. Estimation results for the dependence of WTP on income or per capita GDP with only those study design variables significant at 95% or higher, random effects panel model. Dependent variable is WTP.

	Coefficient	Stand.Err.	z	P>|z	Coefficient	Stand.Err.	z	P>|z
log income	16.95	10.17	1.67	0.09	-	-	-	-
log GDP per capita	-	-	-	-	27.75	15.22	1.82	0.06
specific habitat	70.93	30.62	2.32	0.02	72.87	30.59	2.38	0.01
method	45.84	17.64	2.60	0.00	45.49	18.46	2.46	0.01
constant	-176.84	96.46	-1.83	0.06	-278.77	147.71	-1.89	0.06
n	128				111			
Wald $\chi2$ / $P>\chi2$	19.26 / 0.00				16.48 / 0.00			
R^2 (within)	0.17				0.16			
R^2 (between)	0.10				0.12			
R^2 (overall)	0.08				0.07			
$\sigma\mu$	72.73				73.79			
$\sigma\varepsilon$	40.51				43.54			
ρ	0.76				0.74			

Table 5: Logit model of internal income significance at the 95% level.

	household income				GDP per capita			
	Coefficient	Stand. Err.	z	P>|z|	Coefficient	Stand. Err.	z	P>|z|
Income or GDP[1)]	-0.20	0.07	-2.74	0.01	-0.28	0.15	-1.80	0.07
Studyyear	0.06	0.21	0.30	0.77	0.08	0.17	0.49	0.63
specific species	-2.25	1.18	-1.90	0.06	-2.75	1.19	-2.31	0.02
specific habitat	2.89	3.33	0.87	0.39	-4.30	2.06	-2.09	0.04
save	-7.31	2.90	-2.52	0.01	-2.71	1.54	-1.76	0.08
scope	1.96	2.28	0.86	0.39	0.55	1.69	0.33	0.74
donation	4.60	2.19	2.10	0.04	3.92	1.33	2.94	0.00
method	-13.18	5.46	-2.42	0.02	-4.41	2.00	-2.20	0.03
payment interval	-1.17	1.42	-0.82	0.41	-2.89	1.24	-2.33	0.02
format [2)]					1.45	1.59	0.91	0.36
Constant	-109.97	427.12	-0.26	0.80	-152.11	339.01	-0.45	0.65
N	64.00				80.00			
Log likelihood	-15.4258				-24.99			
LR $\chi 2$ / P>$\chi 2$	56.87	/0.000			53.61	/0.000		
pseudo-R^2	0.6483				0.5175			

1) Income/1000 or GDP/1000

2) Format dropped in regression on income due to correlation problems if included

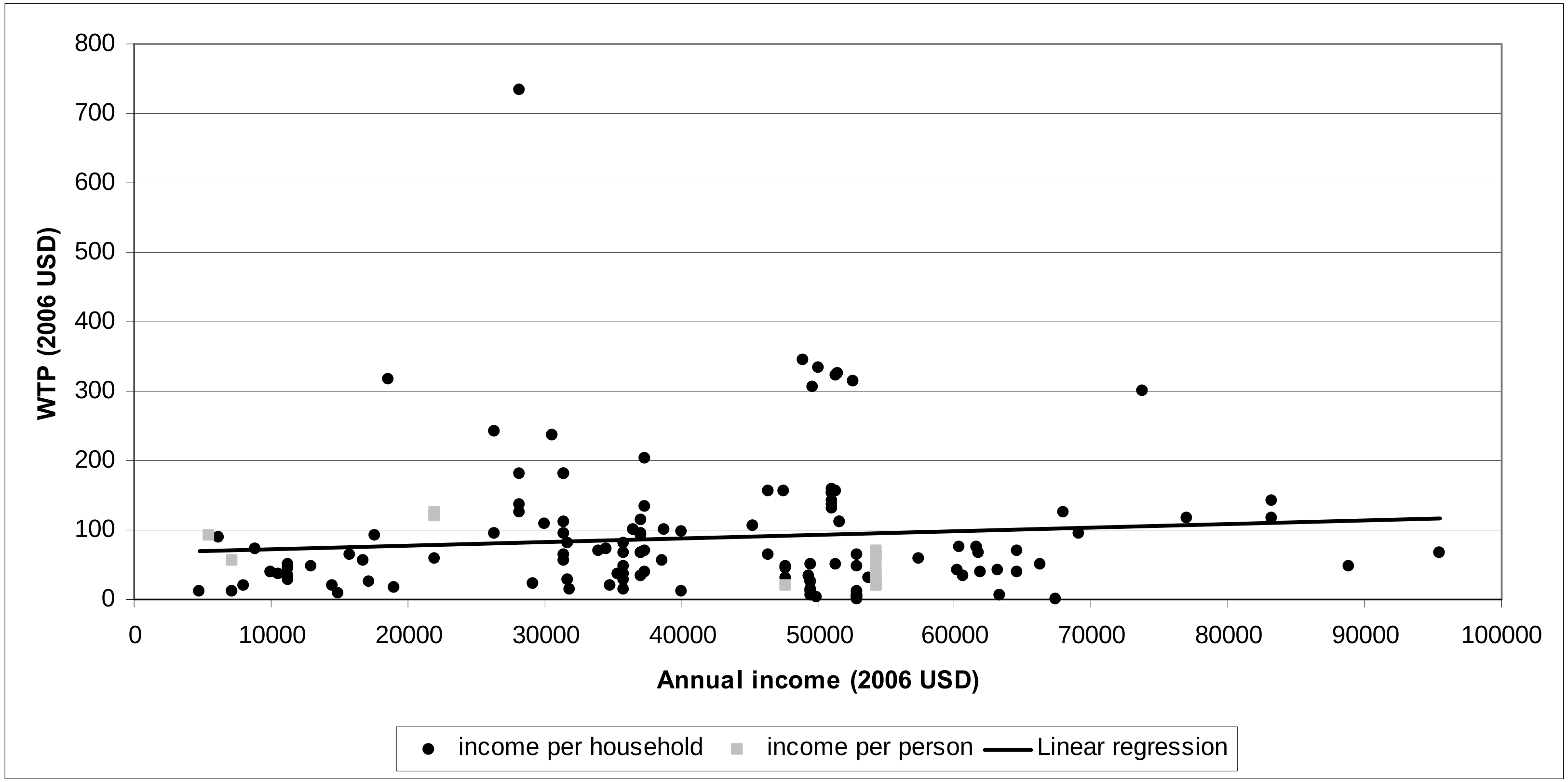

Figure 1.

WTP as a function of gross income (household or personal). Black dots are income measure per household and grey squares are income measures per person. A linear regression is shown.